MIGRATORY BEHAVIOR OF ADULT CHINOOK SALMON SPAWNING IN THE LAKE WASHINGTON WATERSHED IN 1998 AND 1999 AS DETERMINED WITH ULTRASONIC TELEMETRY

by

Kurt L. Fresh
Washington Department of Fish and Wildlife
Olympia, WA

Eric Warner
Muckleshoot Indian Tribe
Auburn, WA

Roger Tabor
U.S. Fish and Wildlife Service
Olympia, WA

Douglas Houck
King County
Department of Natural Resources

Adult chinook salmon destined to spawn in the Lake Washington Watershed (LWW) probably have the most heavily altered estuarine and lowland migratory route to spawning grounds of any salmon population in the region. Conditions the fish encounter along this route can induce a variety of behavioral and physiological responses that can affect their ability to successfully reach spawning grounds and decrease the viability and survival of gametes of fish that do spawn. The objectives of this study were to use ultrasonic telemetry to determine the migratory behavior of chinook salmon spawning in the LWW in 1998 and 1999. Specifically, we sought to determine: 1) the location of migratory corridors and holding areas used by the adult chinook, 2) when and for how long chinook salmon use these areas, 3) transit times and migratory rates from the Locks to spawning areas, 4) whether migratory behavior differed according to when fish entered the watershed and their destination (e.g., hatchery vs. wild), 5) whether behavior varied with fish size and sex, and 6) the relationship of temperature, salinity, and dissolved oxygen levels to fish behavior.

All fish were captured and tagged in the fish ladder at the Ballard Locks. An ultrasonic transmitter (all transmitters were from VEMCO Ltd) was inserted into the stomach of each captured fish, fork length measured, and an individually numbered spaghetti tag inserted just behind the dorsal fin. Each transmitter had a unique code created as a train of six pulses followed by a delay period; six different frequencies were used. Battery life of all tags was rated at approximately 400 days under pulsed operation.

Fish movements were monitored using fixed receiver stations (Vemco Model VR-20) located at the Locks, near the West End of the Ship Canal, at the east end of the Ship Canal (UW), at the mouth of the Cedar River, two miles upstream of the mouth of the Cedar River, at the west end of the Sammamish River (Kenmore), at the east end of the Sammamish River (Marymoor), in Bear Creek, and mouth of Issaquah Creek. A mobile receiver (Vemco Model VR-60) with uni- and multi-directional hydrophones was used to locate fish between receiver stations. The spawning destination of as many fish as possible was determined by recovering transmitters from hatcheries and major spawning streams.

A chronological record of the positions of each fish was created from fixed and mobile receiver data files. For each fish, estimates of travel time (in days) were computed. Some fish passed a receiver site undetected so only partial data was obtained on that fish. Residence and travel time estimates were computed for the Locks, Locks to UW (Ship Canal), UW to Kenmore (Lake Washington), and Kenmore to Marymoor (referred to as residence time in the Sammamish River) as the time elapsed from the last detection at one site to the first detection at another receiver location. Computing residence time in this fashion assumes that fish had left a site after last being detected. At the Locks, residence times should be considered minimum estimates because chinook were present at the Locks for an unknown period before being tagged.

A total of 78 adult chinook salmon were tagged with transmitters in 1998 and 131 in 1999. The average fork length of all fish tagged was 77 mm in 1998 and was 80 mm in 1999. Average size of both males and females was larger in 1999 than in 1998. In 1998, tagging began on 8/4 and ended on 9/28 while in 1999, tagging began on 7/19 and ended 9/21.

The destination of 60 of the 78 fish tagged in 1998 and 107 of 131 fish tagged in 1999 was the LWW (defined as any fish detected on the UW data logger or east of that point). Other fish were either never detected within the LWW, died or shed their tags. In both years, the majority of adult chinook (40% in 1998 and 51% in 1999) were destined for the Issaquah Creek basin (this includes recoveries from the hatchery and creek). Tags were also recovered from the Cedar River, Big Bear Creek, Kelsey Creek, and the University of Washington Hatchery.

Mean residence time of adult chinook at the Locks was 19.1 days in 1998 and 16.6 days in 1999 (only using data for fish tagged after 8/4 in 1999- the residence time using all fish was 18.2 days in 1999). The shortest amount of time spent at the Locks was 0.2 days and the longest was 47 days. There was considerable variation in both horizontal and vertical movements of individual fish. Residence time at the Locks was inversely related to when fish were tagged. In 1998, none of the tagged fish left the locks to enter the LWW until 19 days after tagging began. In 1999, some tagged fish had already entered the LWW within 2 days (based upon their detection on the UW data logger at the east end of the Ship Canal) after tagging began on 7/19. This suggests that the Locks was delaying the entry of some fish into the LWW in 1998. We hypothesize that the delay in 1998 was due to water temperatures that did not drop below 22.0 C until after 8/27. For fish that entered the LWW, 31% in 1998 and 25% in 1999 dropped back below the Locks at least once.

Adult chinook used the Ship Canal primarily as a migratory corridor, typically spending less than 1d in this environment. For example, in 1999, 75% of the fish passed through the Ship Canal in less then 1 day. Travel time ranged from 0.2 days to 7.7 days, and increased with fish size and the latter fish were tagged.

The average time spent migrating from the UW data logger to the Kenmore data logger was 2.9 days in 1998 and 5.9 days in 1999 (all data), ranging from 0.4 days to 33.5 days. Migration time to the Cedar River from the UW was 12.4 days. The first fish was detected at Kenmore on 8/29 in 1998 and on 8/1in 1999 with median detection dates of 9/15 and 9/9 in 1998 and 1999, respectively. In general, fish migrated rapidly through the main basin of the lake and then held near river mouths. This was the same that was followed by fish in Lake Sammamish, rapid migration through the lake followed by holding off the mouth of Issaquah Creek. Behavior of individual fish in Lake Washington varied considerably, however. Some fish spent most of their time below the thermocline while other fish held in and among milfoil beds in shallow water. Some fish wandered around the lake. One fish, for example, migrated from the UW, to Marymoor (extreme east end of the Sammamish River) and back to the UW hatchery.

In 1998, tagged adult chinook were present in the Sammamish River (first detection at Kenmore to last detection at Marymoor data logger) from 8/29 to 10/29 and in 1999 they were detected from 8/3 to 11/3. Mean residence time was 9.4 days in 1998 and 16.9 days in 1999 (using all data). Time spent in the Sammamish River depended on when the fish arrived at Kenmore. For example, in 1999 mean residence time in the Sammamish River was 12 days before the median passage date at Kenmore and 21 days after the median passage date. While in the river, fish held in one of a limited number of pools, often for extended periods, one fish was detected for 24 days in the same pool in 1998. Critical holding areas include natural pools, bridges, and artificial structures (such as deflectors).

We believe that the difference in migratory behavior between the two years was due in large part to the difference in water temperatures between the two years. Temperature in 1998 was much warmer than in 1999 but varied with location and time period; during the early part of the migration in 1998, water temperatures were near lethal in some locations. The most critical stretch in the river is between Lake Sammamish and the mouth of Big Bear Creek because the highest water temperatures occurred in this reach. Other parts of the river benefit from the cooling effect of tributary streams. Fish would clearly benefit from the addition of cool water holding areas in this river.

ACKNOWLEDGEMENTS

The financial support provided by King County was greatly appreciated. We thank the following agencies and staff for their assistance:

WDFW
- **Mark Carr**
- **Mike Mizell**
- **Chris Waldbillg**
- **Dan Steele**
- **Steve Foley**
- **Brodie Antipa**
- **Issaquah Creek Hatchery Crews**

Muckleshoot Indian Tribe
- **Brian Footen**

USFWS
- **Steve Hagar**

COE
- **Fred Goetz**
- **John Post**

King County
- **Steve Aubert**
- **Jean Power**

University of Washington
- **Jim Seagren**
- **Mark Tetrick**

Table 1. Summary table of some of the data on migratory behavior of adult chinook salmon at the Ballard Locks in 1999. All data was included.

Mean Residence Time= 18.2 days
Minimum= 0.2 days
Maximum= 46.9 days

Fallback Rate was > 25%. Overall fallback rate was > 33%. (Fallback was >31% in 1998)

<u>Time of Arrival</u>
1. 25% of the run tagged before 8/3. Residence time= 23.3 d.
2. Middle 50% of the run tagged 8/3 to 8/31. Residence time= 18.3 d.
3. 25% of the run tagged after 8/31. Residence time= 13.4 d.

Variability in behavior- "movers and sitters"

SHIP CANAL, 1999

Percent Passing the UW Data Logger:

25% Passage= 8/23, Migration Time= 1.2 d
50% Passage= 9/5
75% Passage= 9/14, Migration Time= 0.9 d

Earliest Detection at UW

In 1999- 7/20
In 1998- 8/27

The Percentage of the fish leaving the Locks by 8/27 was 0% in 1998 and 23% in 1999.

Most fish traveled the Ship Canal in <1 day.

Travel Time Ranged from 4 hours to 7.7 days (1998).

Bigger fish migrated faster.

LAKE WASHINGTON, 1999

UW to Kenmore

Mean= 5.9 days, Min= 0.4, Max= 33.5
First Detect= 8/1. Last Detect= 11/2.
Median passage date= 9/9
Before median= lake residence was 7.5 days
After median= lake residence was 4.4 days

UW to Cedar

Mean= 12.4 days (+ 13.4 days lake residence)

Bigger Fish Migrated Faster

Fish migrated through main basin quickly and then held near river mouths.

In the lake, fish were

1. **Below the thermocline**
2. **Shallow among milfoil beds**
3. **Close to shore**

Some fish wandered throughout the lake.

SAMMAMISH RIVER, 1999

Leaving Kenmore

- **First= 8/3**
- **Last= 11/2**
- **Median= 9/15**

Passing Marymoor Rowing Club

- **First=8/5**
- **Last= 11/3**
- **Median= 9/24**

Time Between Kenmore and Marymoor= 7 days
Time at Marymoor= 3 days
Time at Kenmore= 7 days

Slough residence increases later in the run

- **Before median passage date= 12 days in slough**
- **After median passage data= 21 days in slough**

SAMMAMISH RIVER

Temperature effects are critical

In the Sammamish River, fish are only detected in a limited number of pools.
Critical areas include those around bridges, artificial structures.

Extended residence in individual pools.

Time Spent at Kenmore was much greater in 1999.

DESTINATION OF FISH

	1998	1999
No. Tagged	**78**	**131**
Shed or Dead	**7**	**6**
Left System	**11**	**12**
Other		**6**
Total Entering LWW	***60***	***107***
Issaquah Hatchery	**21**	**35**
UW Hatchery	**7**	**4**
Cedar River	**3**	**8**
Bear Creek	**3**	**3**
Kelsey Creek	**--**	**3**
Issaquah Creek	**3**	**19**
Likely Issaquah System	**11**	**15**
LWW- Unknown	**12**	**20**